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Understanding consumer food choices & promotion of healthy and sustainable Mediterranean diet and lifestyle in children and adolescents through behavioural change actions: the DELICIOUS project

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ABSTRACT

Over the last decades, the abandonment of traditional dietary patterns, such as the Mediterranean diet, represents an important threat for human health and environmental safeguard. The DELICIOUS project aims to promote healthy lifestyles among children and adolescents by implementing activities and tools to increase the adherence to the Mediterranean Diet with an attention to the environmental impacts of the diet. This study protocol describes the DELICIOUS project as a single-arm, uncontrolled behavioural intervention providing formal and non-formal education activities, development of new snacks and recipe reformulation, web/mobile app development, and physical activities to school children and adolescents in five European countries. The project aims to increase awareness of the nutritional benefits and the sustainability aspects of the Mediterranean Diet and to promote consumers' empowerment through an online platform for sustainable and healthy meal planning in the school canteen.

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Introduction

The double burden of malnutrition is an occurring condition involving the coexistence of the results of both undernutrition (such as, child wasting and stunting) and overnutrition (such as, overweight and obesity) in certain populations (NCD-RisC 2017). It has been estimated that almost 3 billion people worldwide are overweight or obese, while more than 150 million children suffer from undernutrition (Popkin et al. 2020). Most of the concomitant occurrence of both under- and overnutrition is generally reported in developing countries, in which the rising trends in overweight and obesity does not seem to be associated with a reduction in stunting, wasting, and thinness

(Wells et al. 2020). Current specific trends in European children and adolescents are worrying, showing about one third of children aged 7–9 years old and one in twenty adolescents living with overweight or obesity (Mayor 2017). Moreover, cases of overnutrition accompanied with missing the dietary recommendations for micronutrients (representing the so-called “hidden hunger”) can be easily observed in developed countries as well (Amoroso 2017). Irrespective of the geographical area in which malnutrition is observed, people living with poverty seem to face growing trends in obesity rates, widening the disparities and the health gap between the poorest and the wealthiest share of population (Batal et al. 2018). In all cases, malnutrition is associated with a greater risk of a

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variety of non-communicable diseases (including, but not limited to, cardiovascular disease, type-2 diabetes, and certain cancers on one side, and nutritional deficiencies on the other side) and it has been accounted responsible for about 4 million deaths globally (GBD 2019 Risk Factors Collaborators 2020).

Changes in dietary habits over the last decades have been driven by several factors, including increased urbanisation, industrialisation, and food availability (Popkin et al. 2012). Such modernisation of dietary habits has led to an increased consumption of animal products (Miller et al. 2023) and a large variety of energy-rich nutrient-poor foods (Baker et al. 2020). These progressive trends resulted in a substantial abandonment of traditional plant-based dietary patterns towards a more “Westernized” diet (Popkin et al. 2012). Alongside with a general impoverishment of diet quality responsible, at least in part, of the global burden of malnutrition (Miller et al. 2022), are recently under the focus of major attention for their impact on the environment and planetary health (Willett et al. 2019). Current dietary recommendations only rarely take into account the environmental impact of a diet and they also have been demonstrated not to always be in line with the most updated scientific knowledge in terms of nutritional adequacy (Springmann et al. 2020). Improving the sustainability of current diets may play an important role in environmental and health impacts globally and in most regions, especially in high- and middle-income countries (Springmann et al. 2018). Moreover, healthy and sustainable dietary patterns have been estimated to have lower cost in middle- and high-income countries and to be beneficial for socioeconomic development and reductions in food waste (Springmann et al. 2021).

Among the most important traditional and eco-friendly dietary patterns investigated over the last years, the Mediterranean Diet is certainly the most studied (Trichopoulou 2021). The scientific studies on the Mediterranean Diet lay the groundwork during the ‘60s, when the renewed American physiologist Ancel Keys hypothesised that the diet of individuals living in a southern Italian town might have played a role in reducing their risk of cardiovascular disease (Russo et al. 2021). The Mediterranean dietary habits have in fact a much longer history, being the result of the high biodiversity of the geographical area surrounding the Mediterranean basin and the transition of numerous different populations and cultures (Hidalgo-Mora et al. 2020). Notwithstanding a unique “Mediterranean Diet” cannot be observed across the region, with uncountable culinary differences and preferences between and within South European,

North African, and Middle-Eastern countries, there are some major features that could ascertain the main characteristics of a true Mediterranean diet (Godos et al. 2024): this dietary pattern was predominantly composed by plant-derived foods, rich in fruit and vegetable, characterised by frequent consumption of whole grains, legumes, nuts, and seeds; consumption of dairy foods, eggs, fish and poultry was common but its frequency was highly influenced by the geographical location (i.e. people living in the coastal areas would consumed more fish, those with large livestock would consume more dairy, others more eggs and poultry); meats (fresh and cured) were consumed less often, left for specific occasions; sweets were often characterised by natural products, such as sweet fruits and honey, while complex confectionaries were rarely consumed; olive oil represented the main dressing for most recipes; and finally, moderate consumption of red wine was commonly consumed during meals in those countries with no religious restrictions towards alcohol. These features are still in part preserved, but the changes in the food markets, the higher availability of all food products, the economic convenience of industrial unhealthy foods have inevitably changed the dietary habits of individuals living in the Mediterranean area (Martini et al. 2021). More importantly, with generations passing by, there is loss of knowledge of the cultural heritage characterising this area, with a progressive abandonment of the traditional Mediterranean Diet but also a substantial disavowal of the process by the younger generations (Grosso & Galvano 2016). These aspects characterising modern societies embrace a variety of lifestyle habits not just limited to food preferences but also increasing engagement in sedentary activities, poor sleeping habits, general lack of time and money, resulting in a preference for convenience over healthy choices (Godos et al. 2020). The importance of maintaining the traditional Mediterranean dietary pattern alive across the Mediterranean area not only relies on its health advantages, but also on the objective benefits for the environment and a sustainable option for future generations (Godos 2023).

The children and adolescents in the school setting have been suggested to be an optimal target to establish healthy lifestyle behaviours, with previous studies showing substantial improvements in adherence to the Mediterranean diet (Roset-Salla et al. 2016; Gianfredi et al. 2021; Blancas-Sánchez et al. 2022). In this context, the DELICIOUS (UnDERstanding consumer food choices & promotion of healthy and sustainable Mediterranean Diet and Lifestyle in Children and adolescents through behavIOUral change actionS) project

aims to promote healthier lifestyles among children and adolescents in terms of both diet and physical activity by implementing a number of activities and tools to increase the adherence to the Mediterranean Diet in the Mediterranean region with an attention to the environmental impacts of the diet. The school interventions will be designed to deliver healthier and more sustainable meals to children in school canteens, but also to provide them with age- and culture-adapted didactic activities and digital tools to assess the nutritional and sustainable capacity of meals provided.

Study aims

The DELICIOUS project aims to provide a multidimensional intervention in school children and adolescents to increase awareness, knowledge, and adherence to the Mediterranean Diet. The primary outcomes of the study include (i) 12-month changes from baseline in adherence to the Mediterranean Diet, (ii) 12-month changes from baseline in questionnaire scores for knowledge, attitudes, and habits of children regarding adherence to the Mediterranean Diet, and (iii) 12-month changes from baseline in physical fitness. The secondary outcome includes 12-month changes from baseline in body composition.

Methods

Preliminary survey

The project will include a preliminary consumer electronic survey aiming to assess the general level of adherence to the Mediterranean Diet in children and adolescents living in 5 Mediterranean countries (Spain, Portugal, Italy, Egypt, and Lebanon). The survey will be conducted *via* recruitment of parents of children and adolescents aged between 6 and 17 years old from the five Mediterranean countries *via* a consumer database. A target of at least 500 individuals per each Mediterranean country will be set. A variety of tools will be administered in order to investigate factors potentially associated with adherence to the Mediterranean Diet as described in Table 1 (Dutta-Bergman 2004; Serra-Majem et al. 2004; Lazarou et al. 2011; Ajzen 2011; Gréa Krause et al. 2018; Romanos-Nanclares et al. 2018).

Study design and study population

The DELICIOUS project is a single-arm, uncontrolled behavioural intervention study with a transdisciplinary approach (Figure 1). The project is articulated in 9 work packages, each with a specific function (Figure

Table 1. Summary of tools used to assess potential factors associated with diet quality and adherence to the Mediterranean diet.

Tool name	Description	Reference
Mediterranean Diet Quality Index for children and adolescents (KIDMED)	This index is derived from 16 components that summarise the principles of the Mediterranean diet (positive points for at least 2 daily servings of fruit and vegetables, 3 daily servings of dairy products, daily breakfast with grains also consumed at least 5 times/week, daily use of olive oil, 2–3 weekly servings of nuts and fish, and of at least two servings for pulses; negative points for frequent intake of sweets and candies, the use of commercially baked goods and pastries in breakfast, having meals in fast-food outlets, and skipping breakfast) and provides an arithmetic score that ranges from 0 to 12, with higher scores reflecting higher adherence to the Mediterranean diet.	Serra-Majem et al. 2004
Electronic Kids Dietary Index (E-KINDEX)	The index incorporates 3 main domains of questions about (i) food groups intake (13 items), (ii) eating beliefs and behaviours (8 items), and (iii) dietary practices (9 items). The theoretical overall score ranges from 1 to 87, with higher scores indicating healthier behaviours.	Lazarou et al. 2011
Short Food Literacy Questionnaire for adults (SFLQ)	Self-rated food literacy consists of 12 questions, of which six focused on functional skills, such as understanding nutrition information and composing a balanced menu, one focused on interactive abilities such as exchanging nutrition information with family and peers, and another five asked about abilities such as critically judging nutrition information or evaluating the longer-term impact of dietary habits on health. Answers were composed of four- or five-point Likert scales answers providing points for a sum score of the 12 items (maximum score 52) indicating higher food literacy.	Gréa Krause et al. 2018
Healthy-Eating Attitudes to the Child (HEAC)	The index consisted of 8 questions with 2 possible answers (yes/no); each affirmative answer was assigned 1 point and each negative answer was assigned 0 points for a maximum score of 8 reflecting positive attitude towards healthy eating.	Romanos-Nanclares et al. 2018
Multiple constructs on health capability to retrieve health-related information	The tool comprised various constructs, including (i) Health-information functions, (ii) Health consciousness, (iii) Health-information Orientation; (iv) Health-oriented Beliefs. Answers vary, from yes/no format to five-point Likert scales, with higher scores indicating better capability to retrieve health-related information.	Dutta-Bergman 2004
Multiple constructs on barriers and enablers to adhere to a Mediterranean diet	Specific questions concerning barriers and enablers of behaviour change comprised (i) "My child's adherence to the Mediterranean diet would provide him/her...", (ii) Would any of the following groups of influence positively help your son/daughter to follow the Mediterranean Diet?, and (iii) "My son/daughter's intention to follow a Mediterranean diet would be..." with multiple answers options.	Ajzen 2011

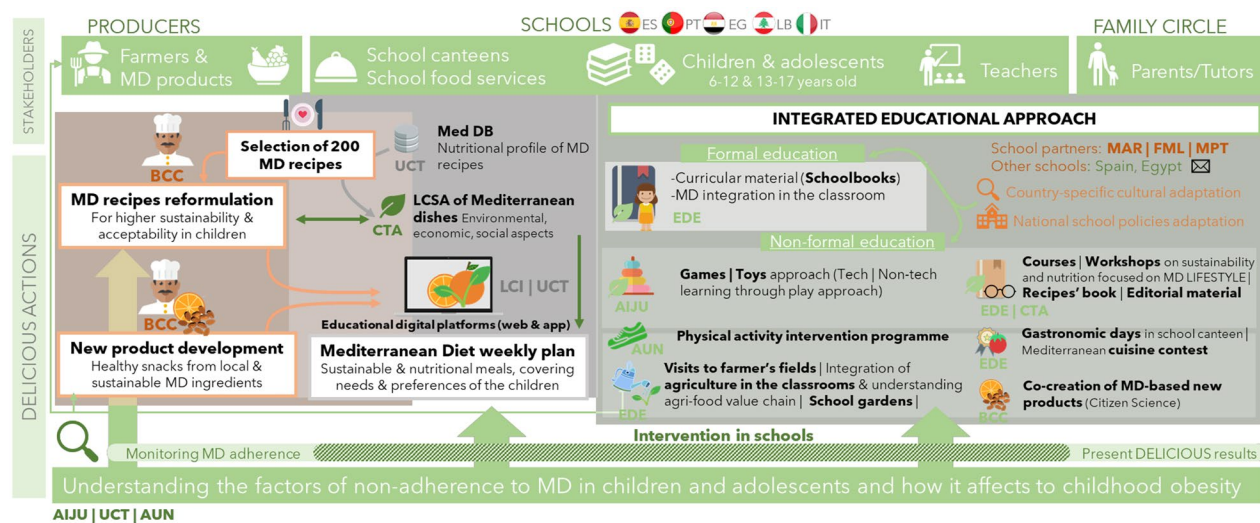


Figure 1. Summary overview of the DELICIOUS project.

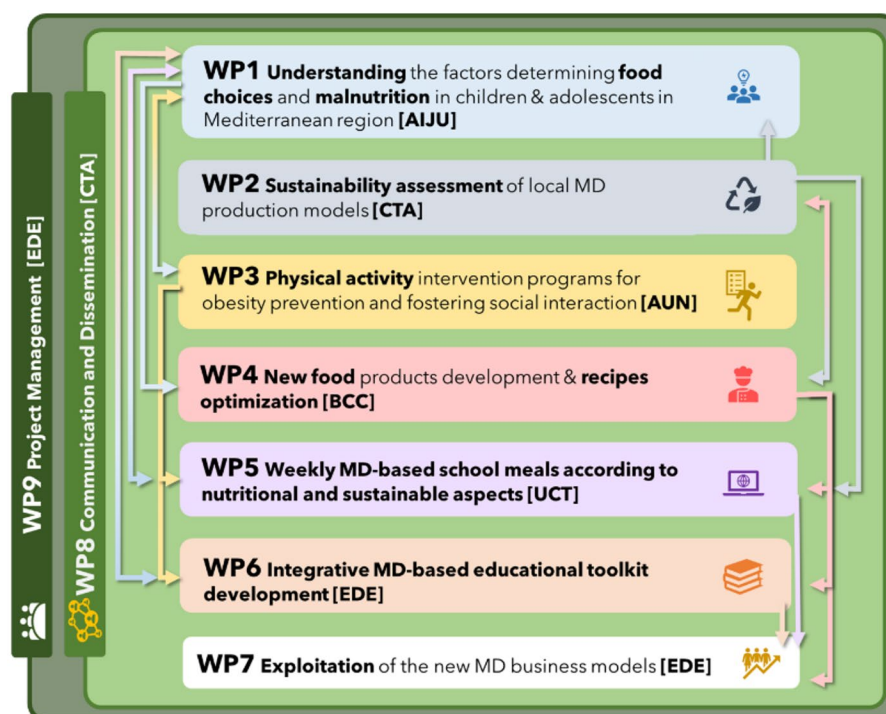


Figure 2. Articulation of the DELICIOUS project through work packages.

2). The study population will involve children and adolescents (6 to 17 years old) from 5 Mediterranean countries (Spain, Portugal, Italy, Egypt, and Lebanon) recruited from 7 schools that agreed to join the project. The participants' schools have been selected from the partners' schools' partnerships, guaranteeing the participation of different Mediterranean countries. Exclusion criterion will be physical impossibility to join the activities related to the project. The study will last 6 months with a pre-post intervention design.

Anthropometric measures

Anthropometric and physical activity data will be collected alongside a dietary assessment before and after the intervention. Weight and height data will be collected and body mass index [BMI = current weight/current height²(m)] and its Z-score [Z-score = mean data - median of reference (P50)/standard deviation (SD)] will be then calculated. The SD BMI Z-score will be used to classify participants into the following groups: malnourished (≤ 1 SD), normal

nutritional status (0.99 to 0.99 SD), overweight (1 to 1.99 SD), and obese (≥ 2 SD).

Adherence to the Mediterranean Diet

The dietary evaluation will be conducted through a 24-h dietary recall used to collect data on food consumption in the previous day. The level of adherence to the Mediterranean Diet will be assessed using the KIDMED index (Mediterranean Diet Quality Index for children and adolescents), which is derived from 16 components that summarise the principles of the Mediterranean Diet prototype (Serra-Majem et al. 2004).

Intervention content

A direct intervention in 7 schools through a multi-disciplinary educational approach combining technological and non-technological, formal and non-formal education, will be conducted (Figure 1). Several tools (Grosso et al. 2013; Tekkurşun Demir & Cicioğlu 2019; Szabo & Lovibond 2022) will be administered to test potential improvements in various aspects of lifestyle behaviours related to healthy eating and adherence to the Mediterranean Diet as described in Table 2.

Educational actions

Various educational activities will be adapted to the needs and cultural context of each country, as well as to the group age needs (6–12 and 13–17 years old) and extended to their family circle through (Figure 3): (a) Formal education: integration of nutritional and sustainability content based on Mediterranean

dietary pattern in primary school curricular material (6–12 years old) according to the National Education Policies of each country. In the case of not acceptance by the school of the adapted content, school materials will be delivered as non-formal education. Further didactic materials regarding topics related to the Mediterranean Diet will be edited for the age sector 13–17 years old, as well as for teachers and pedagogues; (b) Non formal education: consisting in a newly designed global MD-based line of educational material based on consumer behaviour analysis and market studies *in situ*. The non-formal educational activities will be focused on children and adolescents (6–17 years old), family circles or tutors, and the teachers and school staff, to ensure long-term adherence to the Mediterranean Diet.

Development of new snacks and recipes reformulation

The DELICIOUS project will design and produce healthy snacks (minimally processed and using dried fruits/cereals/nuts/algae from local resources) and will optimise traditional recipes of Mediterranean Diet to be added to the menu plans, aiming to achieve higher acceptability by children/families. Country-specific Mediterranean recipes will be reformulated, if needed, according to sustainability and consumer preferences, and further enriched with health-promoting ingredients.

Web/mobile app development

The DELICIOUS project will provide culturally-adapted weekly Mediterranean school meal plans, which will be delivered to the scholars through the school canteens.

Table 2. Summary of tools used in the pre-post intervention phases.

Tool name	Description	Reference
Mediterranean Diet Quality Index for children and adolescents (KIDMED)	This index is derived from 16 components that summarise the principles of the Mediterranean diet (positive points for at least 2 daily servings of fruit and vegetables, 3 daily servings of dairy products, daily breakfast with grains also consumed at least 5 times/week, daily use of olive oil, 2–3 weekly servings of nuts and fish, and of at least two servings for pulses; negative points for frequent intake of sweets and candies, the use of commercially baked goods and pastries in breakfast, having meals in fast-food outlets, and skipping breakfast) and provides an arithmetic score that ranges from 0 to 12, with higher scores reflecting higher adherence to the Mediterranean diet.	Serra-Majem et al. 2004
Multiple constructs on meal habits, food choices, and nutrition knowledge	The tool includes several constructs concerning influences on meal habits, food choices, and nutrition knowledge.	Grosso et al. 2012
Attitude Scale for Healthy Nutrition (ASHN)	The tool consists of 21 items grouped in 4 constructs referring to (i) Nutrition, (ii) Emotion for Nutrition, (iii) Positive Nutrition, and (iv) and Malnutrition. Answers were provided through five-point Likert scales with overall higher scores indicating better attitudes towards healthy nutrition.	Tekkurşun Demir and Cicioğlu 2019
Depression Anxiety Stress Scales for Youth (DASS-Y)	A test comprising 21 questions exploring various aspects of interest, including 'Anhedonia', 'Dysphoria', 'Hopelessness', 'Devaluation of life', 'Self-deprecation', 'Lack of interest', and 'Inertia' in 3 major constructs concerning depression, anxiety, and stress. The answers referring to how the respondent felt during the previous week consisted of 4-point Likert-type scale with higher scores indicating stronger symptoms of anxiety and related feelings.	Szabo and Lovibond 2022

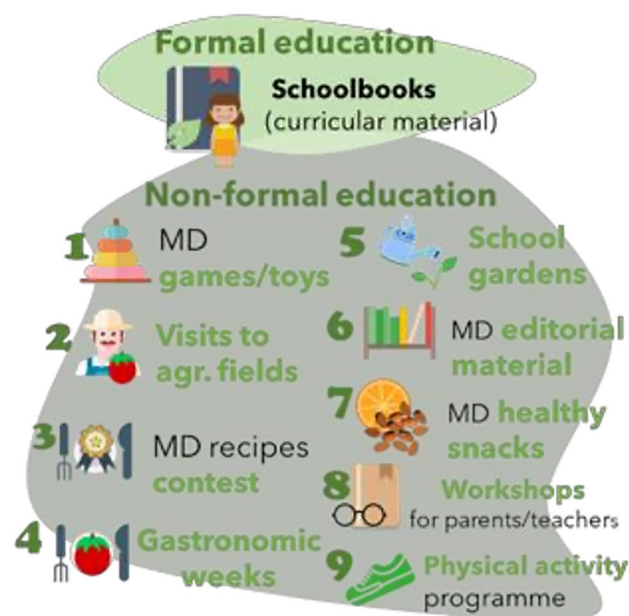


Figure 3. Formal and non formal educational activities implemented in school interventions.

The best option of nutritional and sustainable aspects (local, seasonal foods) based on a personalised profile (allergies or intolerances, religious preferences). To build this digital tool, 200 recipes will be selected, to which nutritional content (macro- and micro-nutrients) will be optimised together with the sustainability profile. To this end, a methodology for life-cycle assessment will be defined and optimised for the purposes of this study. Altogether, this digital tool will have two different interfaces depending on the users: (A) a web platform for schools and school canteens for the preparation of the lunch meal plans; and (B) a mobile application accessible by the general public with alternative dinner plans matched with the school meals.

Physical activities

Physical activity levels will be measured through the International Physical Activity Questionnaire for Older Children (PAQ-C), which includes a panel of questionnaires (five domains) investigating the time spent being physically active in the previous week (Craig et al. 2003). The physical activity intervention will be based on the Be Fit Program (Whooten et al. 2018), a structured physical activity initiative conducted over a period of 6 weeks for (pilot study) and 6 months for basic study. Sessions will be held three times per week, each lasting 40 to 45 min. The program included a diverse array of exercises aimed at enhancing endurance, strength, speed, and coordination, featuring activities such as running, jumping, and various strength exercises. The evaluation of the level of

physical fitness will be performed by the International Physical Performance Test Profile (IPPTP) which contains eight test items representing the five main dimensions of physical fitness endurance, strength, speed, coordination, and flexibility (Bös et al. 2022).

Ethical considerations

Parents of all participants will be informed about the aims of the study. Given the broad variety of activities, students will be enrolled in the study activities unless parents or legal guardians would provide a written form requiring not to include the children. Nominal data will be stored in the participant schools and matched with anonymous codes; only anonymous codes will be used to identify participants in the pre-post questionnaires. All the procedures will be carried out in accordance with the Declaration of Helsinki (1989) of the World Medical Association. The study protocol was approved by the ethics committee of Mondragon Unibertsitatea (no. IEB-20230704).

Sample size

Based on previous findings (García Cabrera et al. 2015), adherence to the Mediterranean Diet in children and adolescents has been shown to be high in 10% to 50% of the reference population. By considering such rates, hypothesising an ideal increase of 20% in the number of children showing medium-high Mediterranean Diet adherence at the end of the case studies, we roughly estimated that the intervention would require a sample size of about 100 participants per sampling unit (school) from 2 age groups (6–12 and 13–17 years old) to evaluate two-sided standardised differences between the pre-post intervention achieving statistical power greater than 0.90 at 5% probability level (P-value), for a total of about 700 participants. Equal participation in both sex and age groups will be aimed.

Statistical analysis

Variables will be examined for normality and skewness (Kolmogorov and Levene tests). Student's t-test and one-way ANOVA or Mann-Whitney U-test and Kruskal-Wallis test will be used for comparisons of continuous variables according to the normality distribution of the sample. Chi-square test will be used to test differences across categorical variables. Pearson or Spearman correlation tests will be performed to test for correlation between linear variables depending on distribution of the sample. Linear regression

models will be performed to assess association between continuous variables (the assumption of linearity for the continuous independent variables and of the variance of the standardised residuals being constant will be assessed through plotting the residuals against the fitted values). Multivariate logistic regression models will be performed to assess the relationship between variables of interest (i.e. consumption of certain food groups or compounds, grouped into quantiles) and the outcome by calculating the odds ratios (ORs) and 95% confidence intervals (CIs). Endpoints will be adjusted for potential confounding factors, such as sex and age. P-values <0.05 (two-tailed) will be considered significant.

Discussion

The DELICIOUS project aims to intervene in younger individuals living in the Mediterranean area in order to promote a healthy Mediterranean dietary habit addressing conscious healthy choices. When approaching dietary shifts in children, diverse factors should be taken into account, including family background or food neophobia (i.e. resistance of the children to consume new food). Previous intervention studies conducted in the Mediterranean geographical area showed a substantial efficacy of educational programs in improving dietary eating habits, attitudes towards healthy eating, and overall adherence to the Mediterranean Diet (Roset-Salla et al. 2016; Gianfredi et al. 2021; Blancas-Sánchez et al. 2022). Intervention studies in children have also demonstrated a potential impact on BMI levels, resulting in improvements in body composition after just 1-year intervention (Martíncrespo-Blanco et al. 2022; Blancas-Sánchez et al. 2022). Other studies provided evidence of efficacy of the use of games to increase knowledge and positive behaviours towards healthy eating in children (Del Río et al. 2019; Roh et al. 2022).

This ambitious educational program will increase awareness on the nutritional benefits (balancing scholar menus) and the sustainability aspects of Mediterranean Diet adherence by increasing transparency of healthiness and environmental impact of Mediterranean recipes and promote consumer empowerment through an online platform for sustainable and healthy meal planning. The multidisciplinary approach aims to maximise the capacity of engagement to recognise the competitiveness of a healthy Mediterranean Diet both in terms of health outcomes and taste preferences. Moreover, particular attention will be paid to the environmental aspects of the dietary choices, providing a sustainability assessment

of the Mediterranean recipes and products along with an involvement of local production and distribution ideally integrating primary producers' cooperative as External Stakeholder. Other web apps have been developed to provide complete meals to the school caterings and canteens, but they often lack evidence-based sustainability data. To our knowledge, this is one of the first intervention projects conducted in school children and adolescents taking into account sustainability aspects of the diet together with the health impact of traditional dietary habits and the promotion of the cultural heritage in the Mediterranean area.

The main potential barrier of the study is the scarce feedback in terms of engagement in non-formal activities, mobile app use, new snacks and recipes, barriers in using formal materials in schools. All partners of the DELICIOUS project will constantly investigate the acceptability of all the aspects of the intervention in each country to guarantee consumer acceptance. Another limitation is the non-randomized selection of the schools, which limit the generalisability of the results. However, the methodology will be free to be applied in other contexts and further explored.

Conclusions

In conclusion, the DELICIOUS project will provide evidence of a multidisciplinary intervention aimed to bring back the Mediterranean Diet as a traditional dietary pattern among children and adolescents living in the area of the Mediterranean Sea. The results of the project could ideally be implemented in European countries and translated into public food and health policies, strategies and guidelines for consumers and food industry, leading to the creation of incentives for the consumption of sustainable Mediterranean foods.

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The DELICIOUS project is carried out by 10 partners with multidisciplinary and complementary backgrounds in Scientific & Technological disciplines, (University of Catania, nutrition; Basque Culinary Center - BBC, food technology; Assiut University, physical education; Globaleduca, software development), and Social Science and Humanities disciplines (Contactica SL, sustainability expertise; Instituto Tecnológico de Producto Infantil - AIJU, games and market analysis expertise; Edelvives, educational and didactic skills) and include a consortium of participant schools (Congregation des Freres Maristes au Liban, Provincia d'Italia dei Fratelli Maristi delle Scuole, and Provincia Portuguesa da Congregacao dos Irmaos Maristas).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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